TECHNICAL AIDS

by
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The Shewhart Control Chart—Tests for Special Causes

THREE years ago, for purposes of convenience and uniformity of application, I collected a set of tests for assignable causes (Figure 1) to be applied to Shewhart control charts for means of normally distributed data. Figure 2 is a set of comments on these tests. Deming (1982) refers to assignable causes as "special causes" in order to contrast them with what he calls "common causes". A common cause is one that affects all the points on the chart, as when a centerline is too high. A common cause is fixed by changing the system. A special cause is fixed by removing the perturbing influence that caused the out-of-control signal.

For my use, Figures 1 and 2 were printed back-to-back on 8.5″ × 11″ yellow card stock and issued to all areas where Shewhart charts are applied. One of the main objectives was to standardize on this schedule of tests so that discussion would be focused on the behavior of the process rather than on what test should be used. Further, control limits are

taken to be three sigma away from the mean unless specified otherwise. If it is desirable to use what otherwise might be called "two sigma control limits", test one is simply redefined to be "one point beyond Zone B."

Tests one, three, and four can be used with p, np, c, and u charts. If the distributions are close enough to being symmetrical, test two can also be used with these charts. Use binomial or Poisson tables to check specific situations.

Conditions that can cause each of these tests to give a signal are illustrated in the Western Electric *Statistical Quality Control Handbook* (1956). The serious user should consult this source. I am pleased to be able to say that the Society has given permission for readers to reproduce Figures 1 and 2 without copyright restriction.

KEY WORDS: Shewhart Control Charts, Tests for Assignable Causes, Tests for Special Causes, $\bar{X}$ Control Charts

References

DEMING, W. E. (1982). *Quality, Productivity and Competitive Position*. Center for Advanced Engineering Study, Massachusetts Institute of Technology, Cambridge, MA, Chapter 7.

WESTERN ELECTRIC (1956). *Statistical Quality Control Handbook*. American Telephone and Telegraph Company, Chicago, IL.
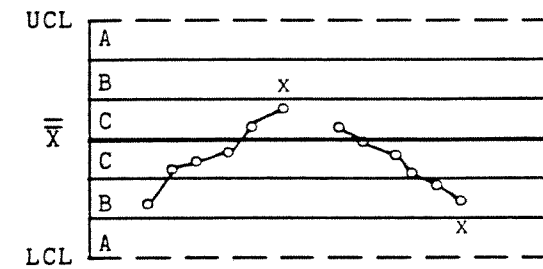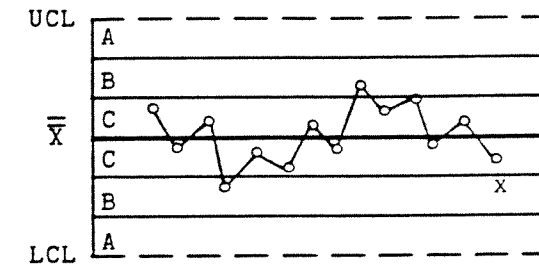
Test 1. One point beyond Zone A
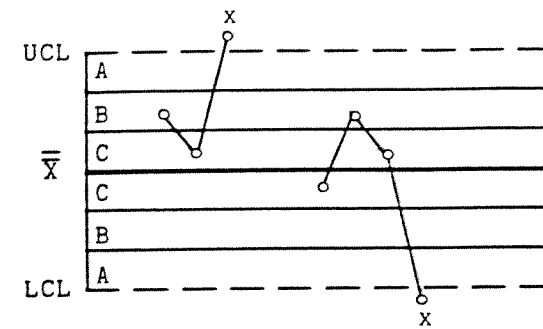
Test 2. Nine points in a row in
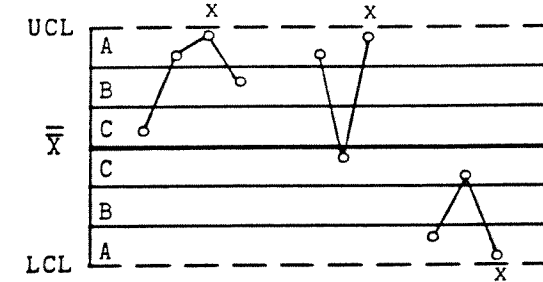Zone C or beyond
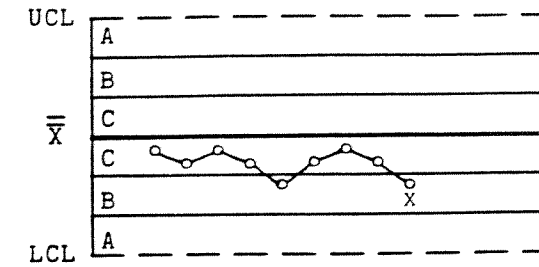
Test 3. Six points in a row steadily
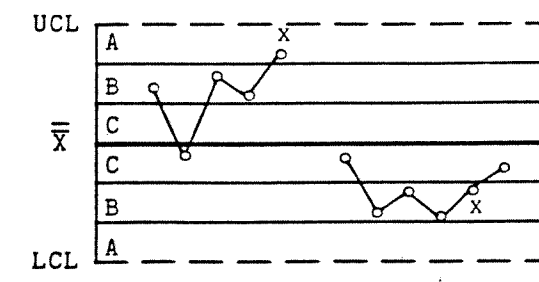increasing or decreasing

Test 4. Fourteen points in a row
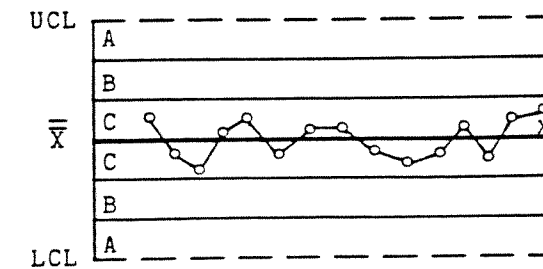alternating up and down

Test 5. Two out of three points in
a row in Zone A or beyond

Test 6. Four out of five points in
a row in Zone B or beyond

Test 7. Fifteen points in a row in
Zone C (above and below
centerline)

Test 8. Eight points in a row on
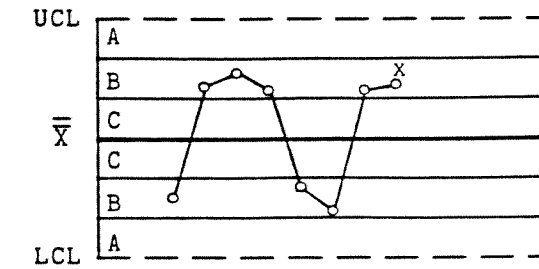both sides of centerline
with none in Zones C

FIGURE 1. Illustrations of Tests for Special Causes Applied to Shewhart Control Charts

SHEWHART CONTROL CHARTS
Notes on Tests for Special Causes

1. These tests are applicable to $\bar{X}$ charts and to individuals (X) charts. A normal distribution is assumed. Tests 1, 2, 5, and 6 are to be applied to the upper and lower halves of the chart separately. Tests 3, 4, 7 and 8 are to be applied to the whole chart.

2. The upper control limit and the lower control limit are set at three sigma above the centerline and three sigma below the centerline. For the purpose of applying the tests, the control chart is equally divided into six zones, each zone being one sigma wide. The upper half of the chart is referred to as A (outer third), B (middle third) and C (inner third). The lower half is taken as the mirror image.

3. When a process is in a state of statistical control, the chance of (incorrectly) getting a signal for the presence of a special cause is less than five in a thousand for each of these tests.

4. It is suggested that Tests 1, 2, 3 and 4 be applied routinely by the person plotting the chart. The overall probability of getting a false signal from one or more of these is about one in a hundred.

5. It is suggested that the first four tests be augmented by Tests 5 and 6 when it becomes economically desirable to have earlier warning. This will raise the probability of a false signal to about two in a hundred.

6. Tests 7 and 8 are diagnostic tests for stratification. They are very useful in setting up a control chart. These tests show when the observations in a subgroup have been taken from two (or more) sources with different means. Test 7 reacts when the observations in the subgroup always come from both sources. Test 8 reacts when the subgroups are taken from one source at a time.

7. Whenever the existence of a special cause is signaled by a test, this should be indicated by placing a cross just above the last point if that point lies above the centerline, or just below it if it lies below the centerline.

8. Points can contribute to more than one test. However, no point is ever marked with more than one cross.

9. The presence of a cross indicates that the process is not in statistical control. It means that the point is the last one of a sequence of points (a single point in Test 1) that is very unlikely to occur if the process is in statistical control.

10. Although this can be taken as a basic set of tests, analysts should be alert to any patterns of points that might indicate the influences of special causes in their process.

FIGURE 2. Comments on Tests for Special Causes